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In reply refer to:
LMSC-HREC PR D867267
17 August 1983

NASA Headquarters
Washington, DC 20546

Attention: Director, Materials Processing in Space, Code EM-7

Subject: Contract NASW-3281, "Manufacturing in Space: Fluid Dynamics Numerical Analysis," Monthly Progress Report

Report Period: 8 July through 7 August 1983

Gentlemen:

This letter is submitted in accordance with the reporting provisions of the subject contract and describes the direction of effort and accomplishment for the period shown above. This study is being performed by personnel in the Computational Mechanics Group of the Lockheed-Huntsville Research & Engineering Center. The NASA technical director for this contract is Bill Oran, Code EM-7.

Background

A number of orbital flight experiments have been planned to test the feasibility of exploiting the low gravity space environment for various manufacturing processes. In particular, a reduced gravity environment has long been considered desirable for reducing buoyancy driven convective motions in liquids used in crystal growing or casting. The purpose of this contract effort is to utilize Lockheed-developed fluid dynamics numerical analysis computer codes to numerically simulate the development of convective motion in experiment configurations of interest to NASA.

(NASA-CR-172944) MANUFACTURING IN SPACE: FLUID DYNAMICS NUMERICAL ANALYSIS Monthly Progress Report, 8 Jul. - 7 Aug. 1983 (Lockheed Missiles and Space Co.) 5 p HC A02/MF A01 CSCL 20D G3/34

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Work Accomplished

Lockheed-Huntsville personnel Robertson and Spradley met in Washington on 2 August 1983 with NASA Hq personnel Drs. Oran and Halpern, and, in a later meeting, with Dr. Dressler at George Washington University (GWU). The numerical simulations described in the last monthly progress report indicated surface convection velocities on the order of 0.005 cm/sec, much lower than the 1 cm/sec range desired for experimental measurements. Dr. Dressler requested that we try decreasing the oil viscosity to get higher velocities. This was done prior to the meeting in Washington, and the velocity results were satisfactory, but the temperature contours were greatly distorted by the higher velocities. The distortion in the temperature gradient resulted in a highly nonuniform surface velocity distribution which, again, is undesirable for experimental measurements. It was decided during the meeting at GWU that we should select an oil viscosity that would yield surface velocities no lower than about 0.1 cm/sec with a temperature difference no lower than approximately 2 C across the free surface. Hopefully, under these conditions, the distortions in the temperature contours would be acceptably small. Based on these guidelines, we selected the 50 centistokes viscosity silicone oil. This resulted in surface velocities of about 0.05 cm/sec. The steady state streamline and temperature contours are shown in Figs. 1 and 2. The distortions even at these low velocities are obviously undesirable.

The results obtained thus far indicate that the degree of distortion in the temperature contours may be predicted, for small distortions, by the following relation:

$$\frac{\Delta x}{L} = 0.037 \, \frac{vL}{\alpha}$$

where Δx is the spatial displacement of the center temperature contour, L is the distance across the free surface, v is the surface convection velocity, and α is the thermal diffusivity of the fluid. For $\Delta x/L = 0.1$, $v = 0.0117$ cm/sec using silicone oil with an α value of 0.0013 cm^2/sec. This velocity is about an order of magnitude smaller than the previously agreed upon guidelines.

Planned Activities

The results described in the preceding section indicate the need for new guidelines in the experimental conditions to be numerically simulated. These will be determined in cooperation with Dr. Dressler at GWU.

Very truly yours,

LOCKHEED MISSILES & SPACE CO., INC.

S.J. Robertson
Computational Mechanics Group

Approved:

L.W. Spradley, Manager
Computational Mechanics Section

SJR:LWS:jp

Attach: Figs. 1 and 2

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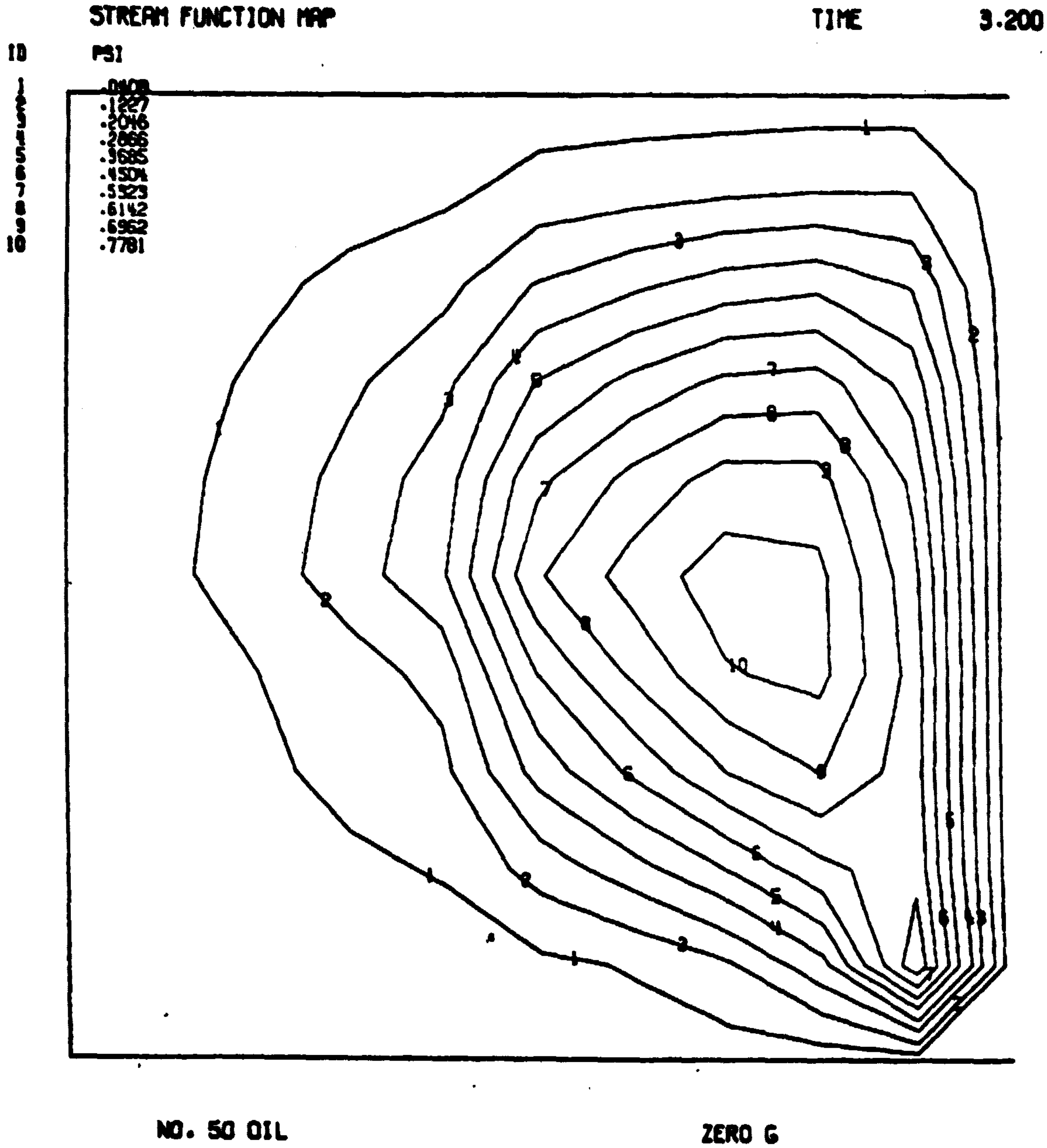

Fig. 1 - Steady State Streamlines

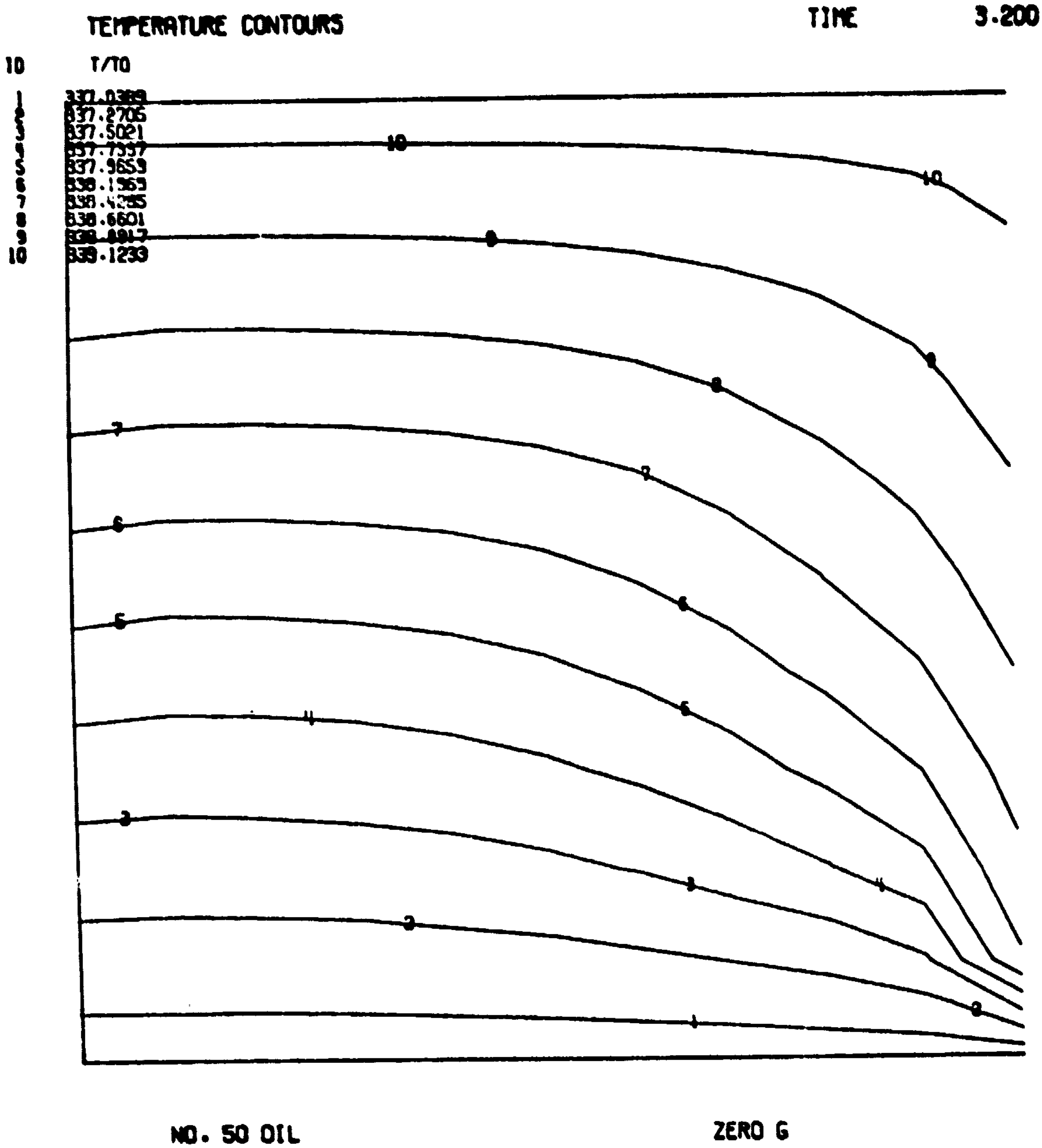

Fig. 2 - Steady State Temperature Contours